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UDC 621.391.015

Z.D. Konoplyanko
Lviv Banking Institute of the University of Banking of National Bank of Ukraine (Kyiv)
zenovij@lbi.wubn.net, zenovij@ukr.net, Ukraine

Addressing RAM for Cross-Interleaving/Cross-Deinterleving Data of Multiple-Valued CIRC-Encoding/Decoding

The article formed the simplestwaysof cross-interleaving/cross-deinterleavingdata,andon thisbasisthe wayofforming sequencesof call addressestoRAM (random accessmemory) cellsforcross-interleaver/cross-deinterleaveror choice ofthier optionsdepending on thenecessaryparameters of codes is proposed.

Introduction

In the telecommunication systems of protection against unauthorized access and means of recording-playback digital data in artificial intelligence systems (such as information channel of space communications, magnetic tape, CD or hard disk and semiconductor storage devices) errors in most cases are dependent (correlated) and are grouped in bundles. To combat them there are used not systematically but extra large *k*-cyclic Reed-Solomon codes (codes CIRC) of cross-interleaving [1-5], which follows the sequence of quasi-random displaced characters (integers from the set $E_q \in \{0, 1, 2, ..., q-1\}$, where q ismultiple-valued finite of Galois field).

Requirements on information technology provide the necessary data rates outstripping supply channels of communication technology. Ultimately, these needs for all occasions will never be satisfied, because the actual data rate of communication channels are theoretically limited by expansion signals of electrical signals, electromagnetic waves or light rays in the relevant environments. Therefore, the best data are transmitted via communication channels with speeds as close as possible to the limits of bandwidth of these channels. At such data rates there are high probabilities of occurrence of so-called errors of these data packets. To deal effectively with burst error that occur at passing data lines (channels) due to noise, usually “corrective” codes of cross-interleaving/cross-deinterleaving data are used, for examplecascading block codes. And among these data Reed-Solomon codes (CIRC) [1-3] are probably the most common.

Cross-interleaving/cross-deinterleaving data in conjunction with various encryption methods, such as scrambling, can be successfully used to combat unauthorized access to data transmittedby communication channels. However, as there is no appropriate cross-interleaving theory, the construction of equipment for cross-interleaving datais usually made by the method of selection. The problems of finding all possible functions of cross-interleaving data and their choice of options depending on the necessary parameters of codes, which are made by cross-interleaving data, still stand over. This article describes the ways of solving some of these problems and so it is important.

The purpose of this writing is the development of the basic theory of elementary cross-interleaving data and on the basis of this theory the way of sequencesof call adresses to the RAM cross-interleaving cells is offered.

Main Part

For cross-interleaving data one can programmatically apply a method (for example tablespace method) of transformation of the set **X** ofcross-interleaved data to the set **Y**of cross-interleaved data. But this approach to the real data cross-interleaving by cross-interleaver in terms of the resource usage of RAM (Random accessmemory) is not rational, and at the infinite set **X** is even unfulfilled. Therefore, this article determined necessary sequence of call address to RAM cells at work of cross-interleaverby the criterion of its minimum number of these cells. When modelling the method ofcross-interleaving tablespace data by cross-interleaver, consecutive record of data in RAM cell is made in accordance with numbers of cross-interleaving table column, and reading of cross-interleaved data is made in accordance with numbers of the selected cells of cross-interleaving stencil. Clearly, to reduce the amount required for the RAM cells,cross-interleaved data is read from the respective RAM cell immediately after recording flowing cross-interleaved data to a RAM cell.

To determine by the tablespace method the sequences of call adress to RAM cells for data cross-interleaving one must prepare the form for the top of the cross-interleaving table (from first to base lines included). This form must correspond to the parameters of function F (whereF is*functionof cross-interleavingdata*). Then one must draw corresponding cross-interleavingstencil in this form and record cross-interleaving data to the cells in the form at the top of the table. The intercrossing must be limited at the top by lines of selected cells of cross-interleavingstencil and at the bottom by the base line.There must be any selected data for cross-interleaving call address to RAM cells.

From the recorded (in the form of the table cells of cross-interleaving) addresses one must to form two cell addresses claiming to RAM: record address and readout address. This can be done, for example, by groups of *n*-1 address in each groupby the following way: one must write out value of the consistent*n*-1 addresses of the first groups of record and readout sequences from the consecutive cells of the base-line of cross-interleaving table (from left to right) and from *i*-th cells of the cross-interleaving stencil respectively.Consecutive *i*-thaddresses of the following groups of address sequences shouldbe written out consistently from each corresponding lower (those whichhave been earilier written out the *i*-th adderesses from) cross-interleaving table cells. If the corresponding lower cell is lower than the base line of the cross-interleaving table, one need to move to the cell of cross-interleavingstencilwhich is located in the same column of the cross-interleaving table.In other words, in cells of *i*-th columns of cross-interleaving tables there are *i*-th address of the data record sequence, and in columns of cells with selected cell stencils there is a cross-interleaving *i*-th address of readout sequence. Determined by this way addresses of sequence record and readout are presented in table 1.

Table 1 – Determination of Required Sequences of Call Addressesto RAM Cells for Data Cross-Interleaving

z	0	1	*2*		4	5	6	7	8	9	10	11	…	107	108	109	110
x_z	0	1	*2*	*j*	4	5	6	7	8	9	10	11	…	107	108	109	110
Record addressin RAM	0	3	7	0	1	4	0	2	5	0		6	…	6	0	3	7
Sense (readout) addressfrom RAM	4	1	0	5	2	0	6		0	7	1	0	…	0	4	1	0
y_z	$y_{ф0}$	$y_{ф1}$	0	$y_{ф2}$	$y_{ф3}$	3	$y_{ф4}$	1	6	2	4	9	…	105	101	103	108

There are other ways to identify sequences of call addresses to RAM cells for data cross-interleaving, for example, formationof a sequence of record address and readout address in accordance with columns of cells with*i*-th selected cross-interleaving cell stenciland *i*-th column of cross-interleaving table (opposite to the above mentioned way).

Similarly, one can determine the sequence of address to RAM cells for cross-deinterleaving data. Form of the table, cross-interleaving stencilfor determination of the sequence of call addresses to RAM cells for data cross-deinterleaving and defined necessary sequence of addresses are listed in table2.

Table 2 – Determinationof Required Sequences of Call Addresses to RAM Cells for Data Cross-Deinterleaving

z	0	1	2	3	4	5	6	7	8	9	10	11	…	109	110
x_z	$y_{ф0}$	$y_{ф1}$	0	$y_{ф2}$	$y_{ф3}$	3	$y_{ф4}$	1	6	2	4	9	…	105	101
Record addressin RAM	0	2	6	0	1	3	0	2	4	0	1		…	2	6
Sense (readout) addressfrom RAM	i	1	0	4	2	0	5	1	0	6	2	0	…	1	0
y_z	$y'_{ф0}$	$y'_{ф1}$	$y_ф$	$y'_{ф2}$	$y_{ф1}$	$y_{ф2}$	$y'_{ф3}$	$y_{ф3}$	$y_{ф4}$	0	1	2	…	100	101

Sequences of call addresses to RAM cells, which have been defined by the tablespace way, areperiodic number sequences of the period T, which can be calculated by formula: T = n LCM$\{\alpha_i$+1) = n LCM $\{\beta_i$+1). Where LCM is the least commonmultiple.Thus, according to the example 1: T = 3× LCM {1, 3, 4} = 36 at cross-interleaving data and T = 3× LCM {1, 2, 4} = 12 at cross-interleaving data.

From the tablespace method for determination ofthe sequence of elements of the set **X**it is follows that at constant n:

a) organization of elements of the set **Y** depends only on the shape of cross-interleaving stencil and signs of cross-interleaving cells in it;

b) formation of the initial elements of the set **Y** depends on the initial displacement of cross-interleaving stencil relatively to c_0-th row ofthe cross-interleaving table.

The method described in this article shows that the minimum number V of RAM cells, required for cross-interleaving data, can be calculated by formula:

$$V = k_{\phi} + n = \sum_{i=0}^{n-1} \alpha_i + n = \sum_{j=0}^{n-1} \beta_j + n.$$

Thus, V = 0 + 2 + 3 + 3 = 8 is at cross-interleaving data and V” = 4 + 3 = 7 is at cross-deinterleaving data.

Note that if cross-interleaver doesn’t store cross-interleaving data, for whichdelays factors are equal to zero, V’ = V - n.

So, the less value the parameters $d_i$of function F possess, the less the minimum number of RAM cells is necessary for cross-interleaving data. So, if cross-interleaver contains RAM with a relatevely small number of cells,in some casesfor clarifying abilities forcross-interleaving data it is necessary to consider abilities for minimization of parameters $d_i$of function F.

Parameters for function F will be called minimized if min$\{d_i\}$ = 0. There are also other definition of “minimization” of the paprameters for function F. For example if $\exists(i)[(d_i)] = 0$], the set of parameters for function F is minimized. Function F with minimized parameters will be called *minimized function of cross-interleaving data* and will be denoted by sing f. For function f it is correctly if: min $\{d_i\}$ = 0. Of all the functions F,

which give one and the same arrangement of elements of the set **X** to the sets **Y**s(with equivalent but not identical sets of their parameters of the set **X)**, function f has sets**D***i* and **H***j* parameters with the lowest values of their respective elements. To minimize function F it is necessary and it is sufficient for each of its parameter $d_i$to subtract the smallest value of these parameters, that does not change the arrangement of elements of the set **X** at sets **Y**s. When checked by d_{if} parameters of function f, then $d_{if} = d_i$ - min{d_i}. So D_{if} .= [0,4,5).

Summary

Fromthe above article the following conclusions may be done:

1. The tablespace method fordetermination of sequence of call addresses to RAM cells for cross-interleaving data is created.

2. Sequenceof call addresses to RAM cellsis determined by the criterion of minimum number of cells, which are necessary for the work of cross-interleaver.

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З.Д. Коноплянко

Адресація RAM для перечередування/деперечередування даних *k*-значного CIRC-кодування / декодування

У статті сформовані способи найпростішого перечередування / деперечередування даних, а також на цій підставі запропонувано спосіб формування послідовностей адрес звертання до комірок RAM перечередувача / деперечередувача та вибір їх параметрів у залежності від необхідних параметрів кодів.

З.Д. Коноплянко

Адресация RAM для перемежения/деперемежения данных *k*-значного CIRC-кодирования / декодирования

В статье сформированы способы простейшего перемежения / деперемежения данных, а также на этом основании предложен способ формирования последовательностей адресов обращения к ячейкам RAM перемежевателя/деперемежевателя и выбор их параметров в зависимости от требуемых параметров кодов.

Статья поступила в редакцию 04.07.2011.